Review Article

FETAL BIOMETRY

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SUMMARY

Fetal biometry with the help of ultrasound scanning provides the most reliable and important information about the fetal growth and wellbeing. A wealth of important and relevant factors is gathered covering the fetal anatomy, physiology and fatal behavior. A good scanning ultrasound machine and an experienced hand are essential for obtaining maximum advantage.

This review highlights the discipline, its significance, uses, difficulties and limitations related to the study designs, cross-sectional and longitudinal, concerned. Various ultrasonic fetal biometric parameters and their significance, in accordance, to assessment of gestational age have also been discussed.

For this review, Medline search was done and the relevant full papers were retrieved. In addition, references from major ultrasound and embryology textbooks were also obtained.

KEY WORDS: Gestational age, Fetal ultrasonic biometric parameters, Fetal biparietal diameter, Fetal head circumference, Fetal abdominal circumference, Femur length.

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INTRODUCTION

Fetal biometry is a methodology devoted to the measurement of the several parts of fetal anatomy and their growth.[1] Fetal growth is defined as the time dependent changes in body dimensions that occur throughout the pregnancy. The growth rate of various parameters is rapid especially in the 1st and 2nd trimesters; they change significantly with the advancement of pregnancy and must be evaluated against normal value at that age.

Fetal biometry can be carried out by two different kinds of studies *viz*: cross-sectional or longitudinal. For *cross-sectional* study, fetuses are examined only once during gestation. This type of study can be performed in a small period of time and the data is easier to collect and analyze statistically. The power of statistics that can be performed on cross-sectional data is suboptimal; they are susceptible to inclusion of fetuses with abnormal growth pattern and/or poorly established gestational age and may not give the desired information.

A *longitudinal study*, on the other hand, is one in which a small number of fetuses are investigated serially, at least thrice during the course of pregnancy. In this type of study, fetal age is established in early pregnancy, abnormal growth curves are easily diagnosed; and the statistics provide more relevant and stronger information. These studies necessitate that same fetuses be scanned during the whole gestation, which considerably increases the time to collect the data and calls for a high motivation on the part of both the mother and investigator.

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Multiple fetal biometric charts are available for prediction of gestational age from a given fetal parameter. These include Measurement of gestational sac, crown-rump length (CRL), fetal biparietal diameter (BPD) and femur length (FL) etc. Other tables allow us to evaluate whether the dimension of a particular parameter is normal for that age. The data analysis includes the calculation of means and standard deviations, expression as *scattergrams* and *regression analysis.*

Professor Ian Donald in Glasgow first used ultrasound scanning for obstetrical purpose in late 1950s. Later in 1960s, fetal cephalometery was employed for fetal biometry.[2-4]

The last two decades have seen a tremendous progress in application of ultrasound as a diagnostic modality revolutionizing the management towards better care. This is particularly due to its non-invasive and non-ionizing nature besides its cost effectiveness leading to wider acceptability.

The exemplary safety record of diagnostic ultrasound is probably an important reason that it has become so widely used.[5] Ultrasound is safe for the patient, the fetus and the sonologist. There is no reported risk of ionizing radiations as in X-rays,[6] or any other known biological or embroytoxic effect. It does not require the injections such as radio-opaque dyes as sometimes needed in radiology.[7]

The single or repeated intrauterine exposure to ultrasound, early or late in pregnancy does not carry the risk of development of lymphatic or myeloid childhood leukemia,[8] as is an attendant of X-rays. It is not associated with any harm to early fetal life, growth and vision or hearing during childhood.[9] Similarly no adverse effects have been observed on neurological development and subsequent school performance of the children.[10]

Fetal biometric parameters: Literature review states that there are multiple fetal biometric parameters in use.

a) Frequently used parameters

Gestational sac diameter (GSD): The gestational or pregnancy sac is usually visible on ultrasound scan at about five weeks after the last missed period. It may be circular, oval or even elliptical in shape with an echogenic margin. An embryonic pole can usually be seen after 6 weeks, and the cardiac flicker is picked up with a real time scanner.[11,12] GSD has been reported as the first ultrasonic parameter to be used for confirmation of pregnancy.

Crown-rump length (CRL): Crown-rump length is one of the most reliable ultrasonic biometric parameter. It is used in the first trimester. By seven weeks, the embryo is clearly seen in the gestational sac and its crown-rump length can be measured in long axis.[13,14] By this time, the yolk sac can be seen in relation to the ventral surface of the embryo. The presence of the yolk sac is deemed to be an encouraging sign of fetal well being and it remains visible until about 10 weeks of gestation.[15]

The CRL is utilized for estimation of gestational age up to the eleventh weeks, with accuracy in 95% of cases, within 2.7-4.7 days.[16] After that the curvature of the fetus affects the reliability of measurement, therefore, from 12th week onwards, the biparietal diameter is considered to be more accurate.

Biparietal diameter (BPD): This parameter is used in the second trimester, from 12th week onwards. It measures the maximum distance between the two parietal bones taken from the leading edge of the skull to the leading edge i.e. outer to inner.[17] It can also be measured from outer to outer table of the skull. This axial plane passes through the widest portion of skull where the continuous midline echo of falx cerebri is broken by cavum septum pellucidum with both the thalami enclosing the slit like opening of the 3rd ventricle of brain

Studies report the growth of the BPD in the mid trimester is linear and rapid and biological variation at each week of gestation is small. The measurement of BPD from 14-26 weeks predicts the correct duration of gestation to the extent of $\pm$9 days in 95% of cases, however, the measurement of the parameter in second trimester (16-20 weeks) routine scan is performed in all good antenatal care centers.

At times, when the fetal head may be short and wide (brachycephaly) or long and

flattened (dolicephaly), the assessment of age from BPD will be under or over estimated. Therefore, if the shape of head appears brachycephalic or dolicephalic, the cephalic index is calculated; and if found to be outside the normal range, the head circumference should be used to estimate age.

$$\text{Cephalic index} = \frac{\text{Biparietal diameter}}{\text{Occipito frontal diameter}} \times 100$$

(Normal Range = 75-85%)

Head Circumference (HC): This parameter is used in the third trimester along with other parameters such as FL.[18-20] It is measured at the same level at which the BPD is taken by using the ellipsoid mode of the machine and adjusting the elliptical calipers to the outer margin of the skull table. The accuracy of this parameter is ±2-3 weeks with 95% confidence interval.

Abdominal Circumference (AC): This ultrasonic fetal biometric parameter is less used for the assessment of gestational age. It is however, more used for monitoring fetal growth, especially in the third trimester and for estimation of fetal weight.[21] The abdominal circumference is taken at the level where the umbilical vein enters the left branch of portal vein; alternatively, a scan at a slightly lower level showing a short segment of the umbilical vein may be taken. The outline of the abdomen should be as circular as possible.

Until 36 weeks of pregnancy, the head circumference is larger than the abdominal circumference, the HC: AC ratio is therefore more than 1, but after 36 weeks, the AC catches up with the HC, and then continues to grow at a faster rate, so that the ration of HC to AC near term becomes less than one. [22]

Femur Length (FL): Femur length is a very useful biometric parameter used in the second and third trimesters of pregnancy. It grows linear throughout and is best measured after 14 weeks of gestation.[23-25]

The diaphysis is measured from the greater trochanter above to the lateral condyle below. The outer border of femur is straight and the inner border is curved normally.[26] The accuracy of gestational age calculation by FL is within 6-7 days of menstrual age at 95% confidence level.[27] These four parameters are most frequently used for the estimation of gestational age and sometimes considered as the 'gold standard' and they collectively assess the gestational age to the highest degree of accuracy

Parameters, less frequently used in the discipline of fetal biometry, include the fetal transverse thoracic diameter, thoracic circumference, measurement of long bones, orbit and lens dimensions and fetal binocular distance. The thoracic diameter and circumference is specially used in assessment of fetal weight.

Fetal orbit, lens dimensions and fetal binocular distance are used as a predictor of gestational age.[28] The variability (±2 SD) associated with predicting menstrual age using binocular distance is ±14 days between 14 to 27 weeks and ±24 days between 29 to 40 weeks respectively.[29]

Fetal long bones are also used for the assessment of gestational age but are more in use for detecting divergence from normalcy e.g. suspected cases of skeletal dysplasias. Bones used for the estimation of gestational age include fetal humerus, radius, ulna, femur, tibia and fibula.[30-33] The correct evaluation of gestational age is possible every two weeks by assessing all these bones except femur where it is possible every week before 28 weeks and every 2 weeks after 28 weeks.

These biometric parameters are rarely used as some are technically difficult to measure. The size of the cerebellum and transverse cerebellar diameter is considered as a useful biometric parameter in estimating gestational age in the second trimester.[34] Fetal clavicular measurement is used in evaluation of gestational age and estimating fetal weight. Studies suggest that the gestational age in weeks is approximately equal to the length of the clavicle as expressed in millimeters.[35] Interclavicular distance in cases of breech presentation has an added benefit to assess the capacity of pelvis of the mother for subsequent delivery.

Fetal liver and kidney at times are used for fetal biometry.[36,37] Parameters such as fetal

scapula, sacral length, fractional spine length, foot length fetal ear length and the fetal nasal bones are used for dating the fetus at times. Fetal nasal bones are used, in addition, to detect cases of trisomy 21.[38-42]

DISCUSSION

Fetal biometry is of great interest in obstetrical practice. It is helpful in the estimation of gestational age especially in the women who do not remember the dates of their last menstrual period or whose fundal height on abdominal examination does not correspond to dates. The practice of assessing gestational age in early gestation is valuable in detection of growth aberration in later stages of pregnancy. In addition, fetal biometry distinguishes the normal from abnormal fetal structures.

Prenatal measurement of fetal parameters and estimated size and weights vary among different populations, depending upon their racial, demographic characteristics and nutrition. It is therefore important that fetal biometry be performed for local population and local charts of normal biometry be constructed and followed for these populations and ethnic groups.

The standard of fetal ultrasound biometry was started after Willocks[43] et al published, probably the first paper, on fetal ultrasound cephalometery in 1964. Later, in 1968, fetal cephalometery was included in routine fetal biometric scans. Many reference charts and tables have been published since then. However, a number of these were produced using old ultrasound equipment with low spatial resolution in different ultrasound velocities compared with today's modern real-time scanners which have not only opened up improved measurement technique but also provide us with multiple fetal parameters. Several of these charts, however, have methodological flaws, falling short of the ideal attributes of gestational age related reference curve design, namely: non-identification of the statistical method of analysis, a supernormal data set, inadequate account in variability of measurements with gestation and failure to present scatter diagrams. In the publications of Altman and Chitty, methodological guidelines were created for the construction of fetal biometrey charts.[32]

The ultimate goal of fetal biometry is to enable the user to predict information concerning a fetus and to verify how closely the fetus confirms to the prediction.

While constructing the fetal biometry charts, the statistical justification of the sample size is as necessary as the selection of study design type, so that the results may subsequently be generalized to the whole population or at least to the concerned ethnic group. Mean and standard deviation values of the parameter(s) are computed. The smaller the standard deviation, the less is the variability of the sample around the mean. The standard deviation is also used to define the statistical limits of 'normality'. These intervals are called confidence limits. Traditionally, the confidence limits are set at the 5^{th} and 95^{th} percentiles. The values of 5^{th} and 95^{th} percentiles suggest the lower and the upper limits of normal reference intervals or normal ranges for the selected parameter. Scattergrams are constructed and regression analysis is done yielding a specific regression equation that enables one to predict the fetal gestational age once the specific values of fetal parameter is known.

Fetal biometric studies reported from Iran, Oman, Cameron, Bangladesh, Pakistan and Israel describe the uniqueness and specification of different fetal parameters for their own populations.[44-49] Ethnic variations have also been described. Therefore, biometric curves for one population may over or under estimate the fetal age when used for another population with different demographic characteristics. Thus, the construction and use of biometric normograms specific for populations and ethnic groups is always recommended.

CONCLUSION

Fetal biometry is a discipline devoted to the measurement of the several parts of fetal anatomy and their growth. The real-time ultrasound scanners have given a number of ultrasonic biometric parameters. The most

commonly used among these are fetal biparietal diameter, head circumference, abdominal circumference and femur length. In the absence of known date of last menstrual period or where fundal height does no agree with dates, these parameters are valuable in estimating the gestational age of the fetus. To offset difference in growth of these parameters in different populations, it is important to construct and use ultrasonic fetal biometric parameter specific to the population and ethnic groups.

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